

Building Array Wind-Tunnel Experiments

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For hazard-response applications, new transport and dispersion models are being developed to track toxic agent plumes as they disperse through cities. To be confident in the model predictions, urban data sets are needed for model testing and evaluation. Although field experiments are essential for this purpose, they are expensive, time-consuming, and typically provide fewer measurements than desired. Wind-tunnel experiments are an excellent supplement to field experiments. They provide high density measurements around reduced-scale building clusters at a relatively low cost. In addition, the wind conditions can be controlled and the experiments can be prolonged and repeated until meaningful statistics are obtained.

Under the Chemical Biological National Security Program (CBNP), Los Alamos and Lawrence Livermore National Laboratories contracted the US Environmental Protection Agency to perform experiments around building arrays in their wind tunnel. These experiments were intended to provide high density, quality measurements around building arrays for rigorous model evaluation and testing. Two building arrays were studied: a 7 row array with one wide building per row and a 7 row by 11 column array of cubes (Fig. 1).

Because wind and turbulent mixing are very important in determining the transport and dispersion of plumes, the experiment focused on obtaining a

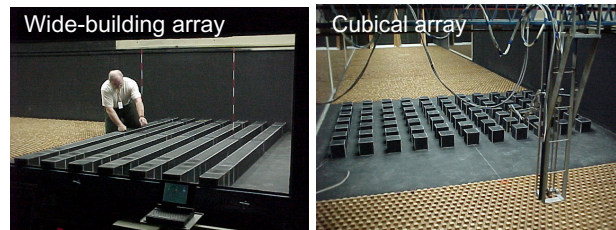


Figure 1. The 7x1 wide building array (side view) and the 7x11 cubical array (looking upstream) in the USEPA Meteorological Wind Tunnel. The tunnel is open-return with a test section 3.7 m wide, 2.1 m high and 18.3 m long. Airspeed can be varied from about 0.3 to 8 m/s.

high density of both mean and turbulent flow measurements around the buildings. Figure 2 illustrates the density of the wind measurements along the centerline. Velocity measurements were made to within 1/10 building height of the obstacle surfaces using a pulsed wire anemometer, a probe specifically designed for regions of high turbulence with flow reversals. A clockwise-rotating vortex fills each street canyon and a rotor develops upstream of the first building. Reverse flow is visible along the rooftop of the first building due to flow separation. The leading edge is also a strong producer of turbulence, as shown by the TKE plume that emanates from the front building corner.

For the 7x11 array, velocity measurements were also taken off centerline in order to better understand the three-dimensional character of the flow. Other measurements included pressure readings

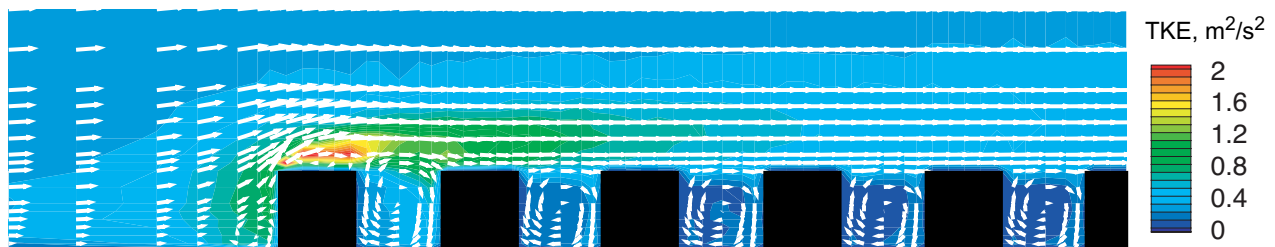


Figure 2. Time-averaged measurements of the mean wind and turbulent kinetic energy (TKE) for the first 6 rows of obstacles in the wide-building array. The base of each arrow represents a measurement location.

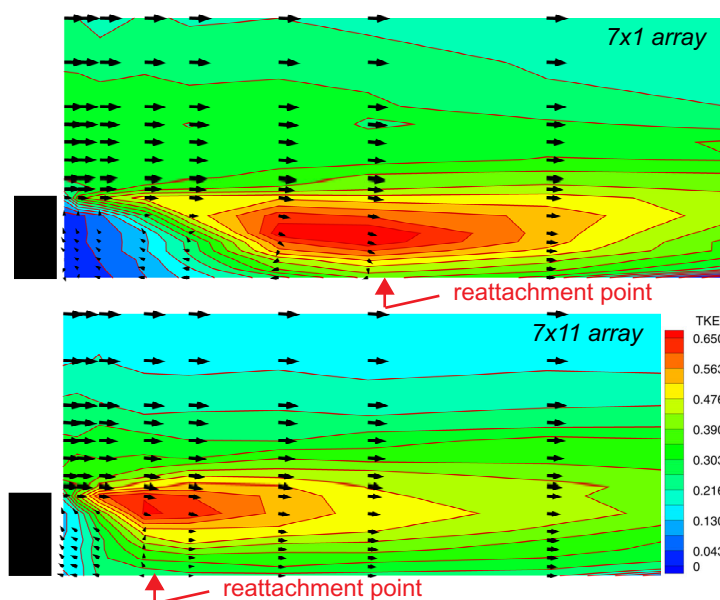


Figure 3. Comparison of the measurements of the mean wind and turbulent kinetic energy behind the last row of the (top) 7x1 wide-building array and (bottom) 7x11 cubical building array.

on building faces in the 7x1 array and concentration sampling throughout the 7x11 array for a point-source tracer release.

A comparison of the wind and turbulent kinetic energy (TKE) fields measured downstream of the two building arrays reveals large differences between the two cases (Fig. 3). For example, the TKE maxima covers a much smaller area for the 7x11 case and doesn't extend as far downstream. In addition, the size of the cavity is much smaller for the 7x11 case, and the recirculation in the cavity is weaker. Close to the surface at the back wall, there is actually a counter-rotating vortex that shows up in the 7x1 case.

The data from these wind tunnel experiments have already been used by CBNP researchers to test and improve their urban transport and dispersion models (e.g., Chan et al., 2001). It has also been given to researchers at DoD agencies and universities for similar model evaluation efforts (e.g., Yee et al., 2001). The data is proving useful due to its spatial density and because it contains both mean and turbulent components of the velocity field. In addition, being able to simulate the differences

between the two building array cases will provide rigorous tests for the numerical models. The wind-tunnel experimental data sets will be extremely useful in quantifying the capabilities of urban dispersion models and provide an indispensable supplement to field data, such as that obtained in the recent CBNP-sponsored URBAN 2000 campaign in Salt Lake City, Utah.

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